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MOTORWAYS OF THE SEA

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Activity 2 - Concept study on next generation icebreakers

Sub activity 2:1
Atle/Urho model test,
Further testing of other new concepts
New “Loose Bow”-concept,

Sub activity 2:2
Desktop study on fuelling possibilities
Sub activity 2:3
Study on relative efficiency between models
Sub activity 2:4, 2:5 and 2:6
Desktop study on different ownership, chartering and operating arrangements. Study on different financing options for new icebreaker.

Generally Act 1 & 2 provide tools to decision support for composition of next generation icebreaker fleet including financing and service concepts

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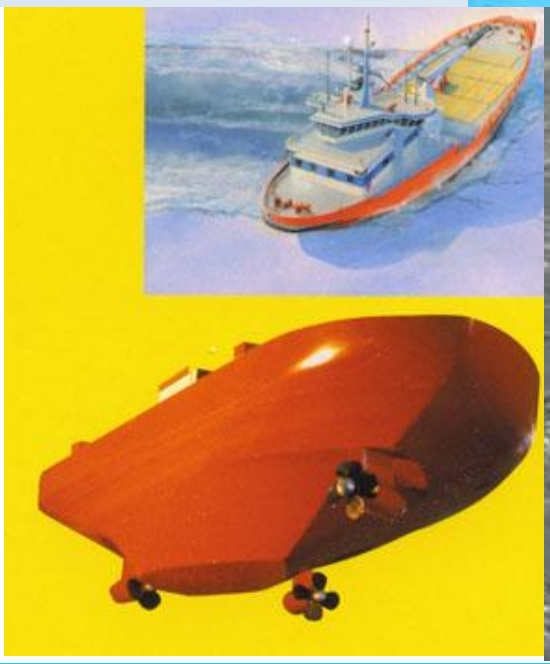
"Different horses for different courses"




URHO


ZEUS
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OTSO


U
UGLAND

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Replacement of ageing infrastructure icebreaking capacity

- Worlds infrastructure icebreaker fleet is ageing, same applies to Baltic icebreakers
- Icebreakers differ, different locations and operations require different capabilities
- Reliable and cost efficient icebreaking capacity to infrastructure winternavigation, chartered from mature commercial icebreaking market, is still far in the future.
- Real increase in utilisation rate for icebreakers which form the core of area specific icebreaking capacity, how intimidating it might sound, is economically very challenging. On the other hand, for additional capacity this concept could be efficient in the future.

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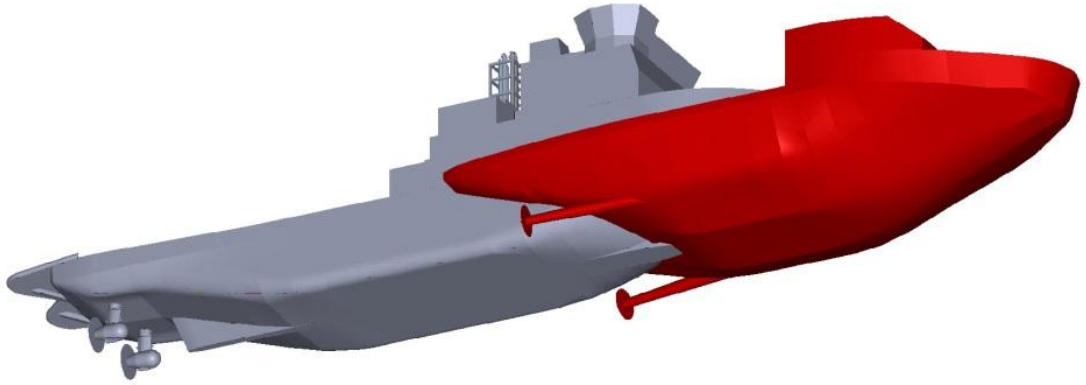
WINMOS Final Seminar 07.04.2016

Consulting Naval Architects & Marine Engineers

Removable icebreaker bow concept



Harri Eronen

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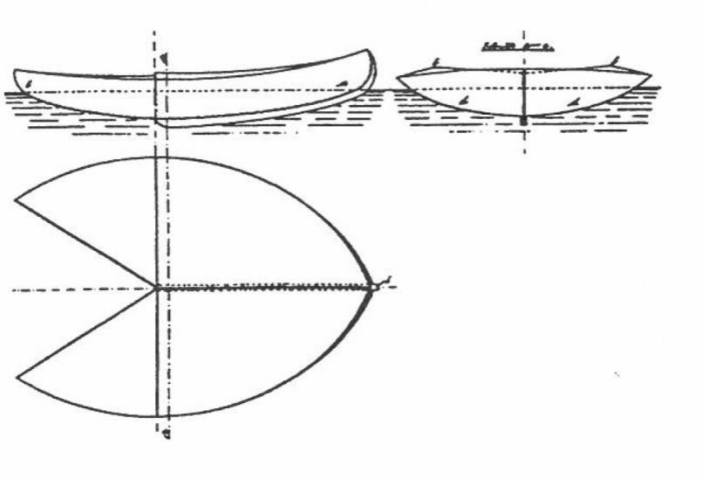
Removable bow – old invention

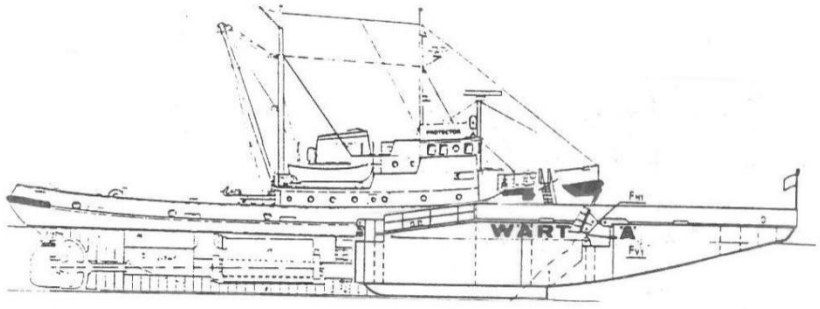
1892 German patent of icebreaking bow to be placed in front of a ship

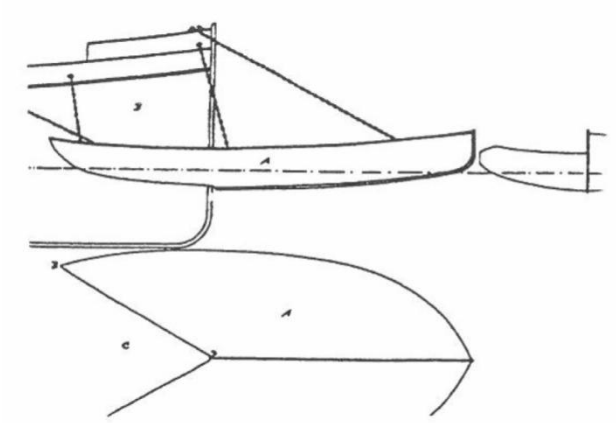
- Used generally e.g. in Dutch rivers

Spoon-shaped removable Wärtsilä bow from 1986

- Used with tug Protector e.g. in lake Saimaa as an icebreaker







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ILS Removable icebreaker bow concept

General

The idea of the removable bow icebreaker is based

- on the use of a pusher vessel of smaller size and lower power than conventional icebreaker
- connect it to a removable bow with propulsion.
- The pusher can be e.g. an existing vessel or a newbuilding optimized for its primary tasks.
- In this way the investment costs are limited to the construction of a removable bow with propulsion.

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Design requirements

- Speed in 0,8 m level ice ahead min about 6 knots (high enough escort speed)
- Total propulsion power about 11 MW
- Waterline breath of removable bow about 24 m
- Fixed coupling of pusher and removable bow
- The ice strengthening of the removable bow and its propulsion to correspond present baltic icebreakers
- The pusher ice class to be min 1A Super

I.e. removable bow icebreaker is designed for Baltic ice conditions excluding hard Golf of Bothnia operations.

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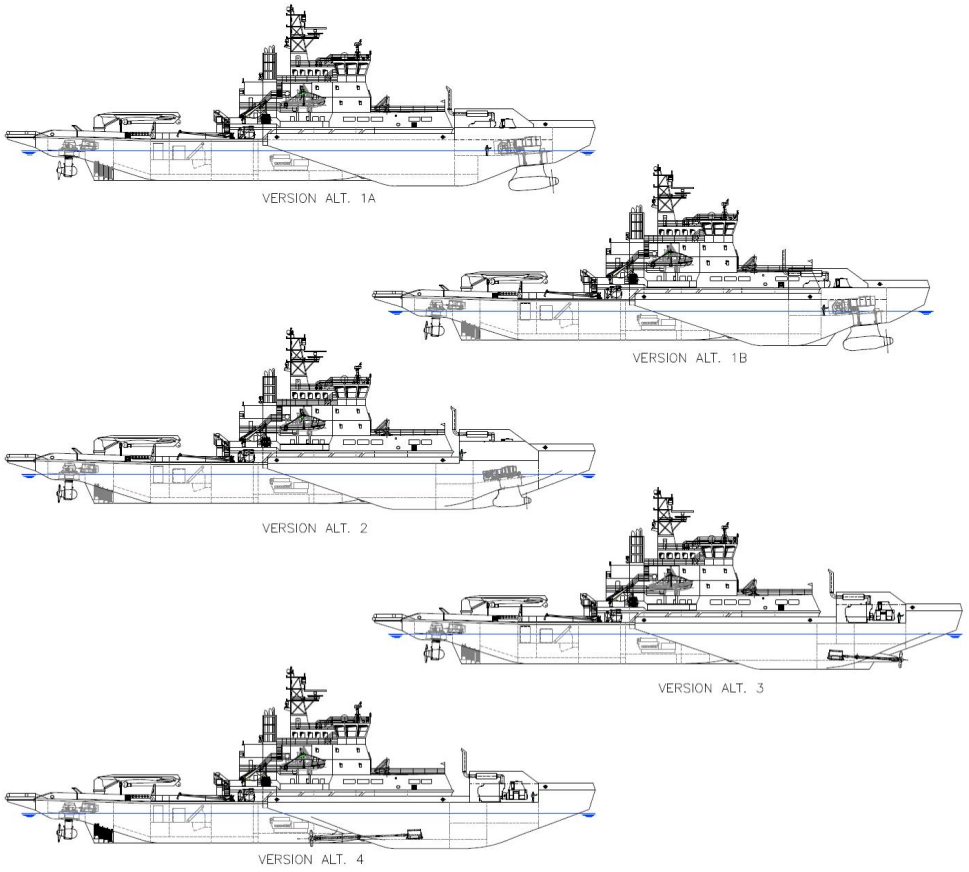
Studied propulsion alternatives

Version alt. 1A/1B
- 1x6 MW pulling azimuth at bow

Version alt. 2
- 2x3 MW pulling azimuth at bow

Version alt. 3
- 2x3 MW conventional shafts at bow

Version alt. 4
- 2x3 MW conventional shafts at stern reamer area



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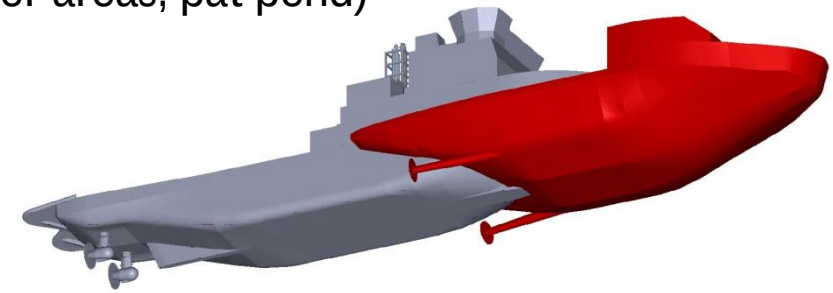
Model tested version

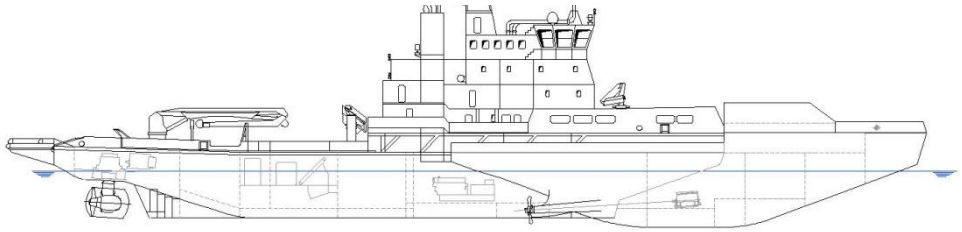
Removable Bow, alt 4 (conventional shafts at reamer areas, pat pend)

Propulsion power	2x3 MW
L	50,6 m
Bwl	24,0 m
T	6,0 m



Pusher (multipurpose oil and chemical recovery vessel Louhi)

Propulsion power	2x2,7 MW
L	71,4 m
Bwl	14,5 m
T	5,0 m
BP	64 t



Combination (The removable bow with pusher results in an icebreaker hull form with reamer bow and highly inclined sides)

Propulsion power	11,4 MW	T	6,0 m
L	93,0 m	BP	130 t
Bwl	24,0 m		

Target of the model tests

The Target of the model tests was to study the characteristics of:

- Removable bow icebreaker concept generally compared to conventional icebreaker designs and
- To test the novel propulsion system

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The new operational characteristics in ice were specially studied

In heavy ice channels and ridges the bow propellers have

- direct interaction with ice
- and also the suction and flush of the propeller flow

are used to

- Break heavy channel/ridge at vessel sides
- Flush the vessel sides and push the ice floes aft

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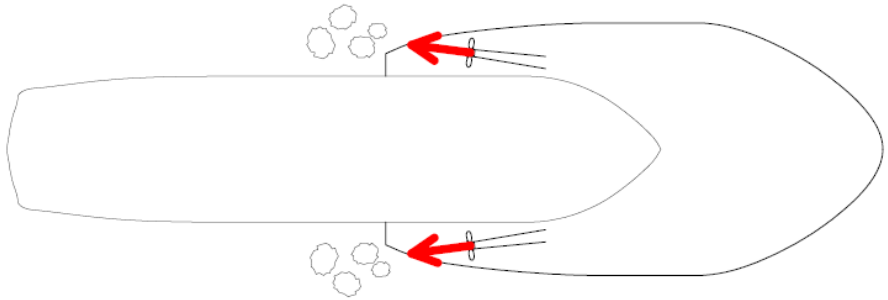
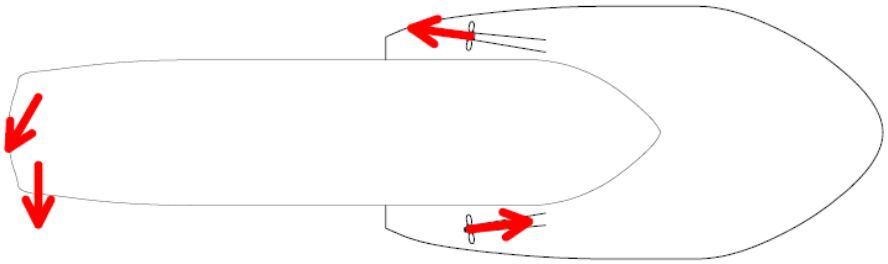
The new operational characteristics in ice were specially studied

This, together with the wide smoothly shaped reamer bow makes it possible to go through heavy ridges continously without ramming.



In manouvering the use of the high steering moment, given by the bow reamer propellers, adds vessels manouvering performance.



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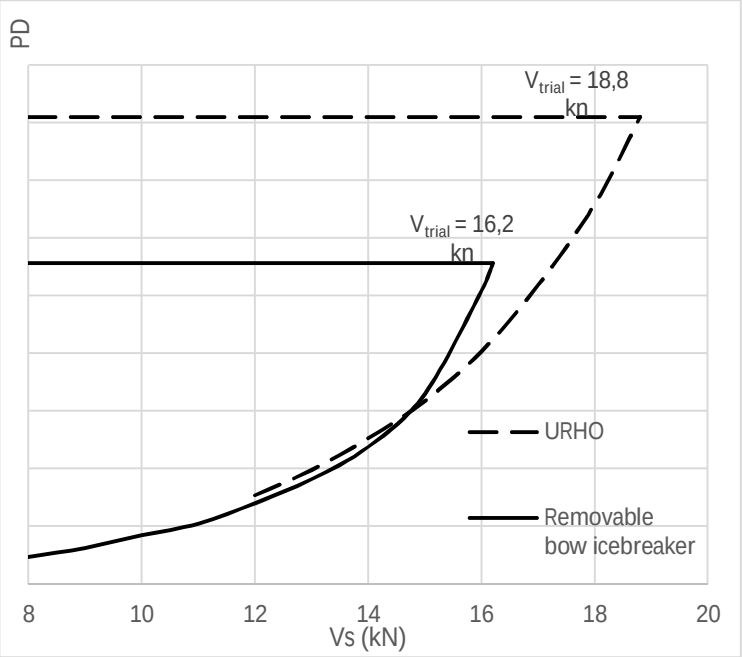
Open water model tests

The main target of the open water model tests was to measure values needed for the ice model test analysis.

Tests included:

- Propeller open water tests
- Bollard pull and towing tests both ahead and astern
- Resistance tests
- Self propulsion tests



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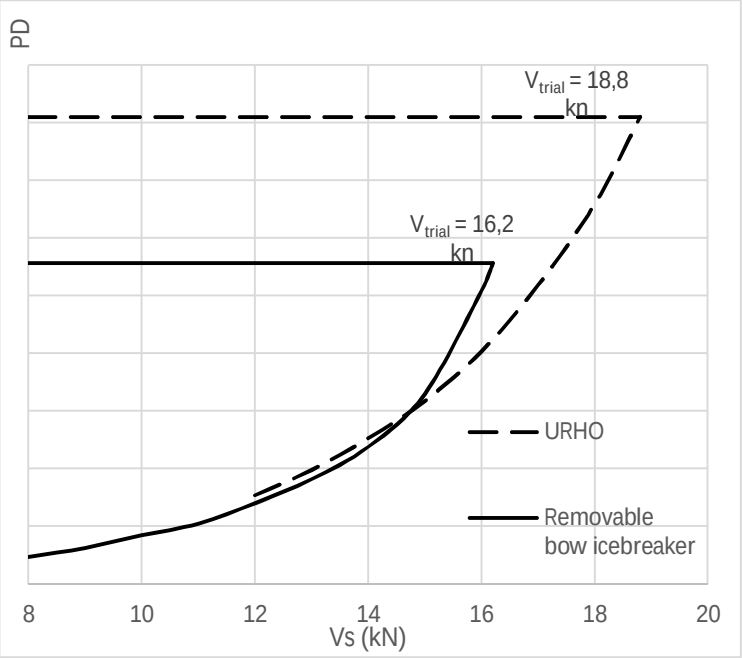
Open water model tests

It can be seen that

- The propulsion power is at the same level as in Atle/Urho class
- The max speed of the removable bow icebreaker is over 16 knots.
- The power needed in open water is lower than that of the multipurpose icebreaker



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Ice Modeltests

- Level ice ahead (0,6 m/0,87 m)/astern (0,6 m)
- Consolidated channel ahead/astern (1,2 m)
- Unconsolidated channel ahead (1,8 m)
- Breaking out of channel
- Consolidated ridge (Urho´s ridge 9-5 m) ahead
- Consolidated ridge (6 m) ahead and astern
- Turning tests ahead and astern

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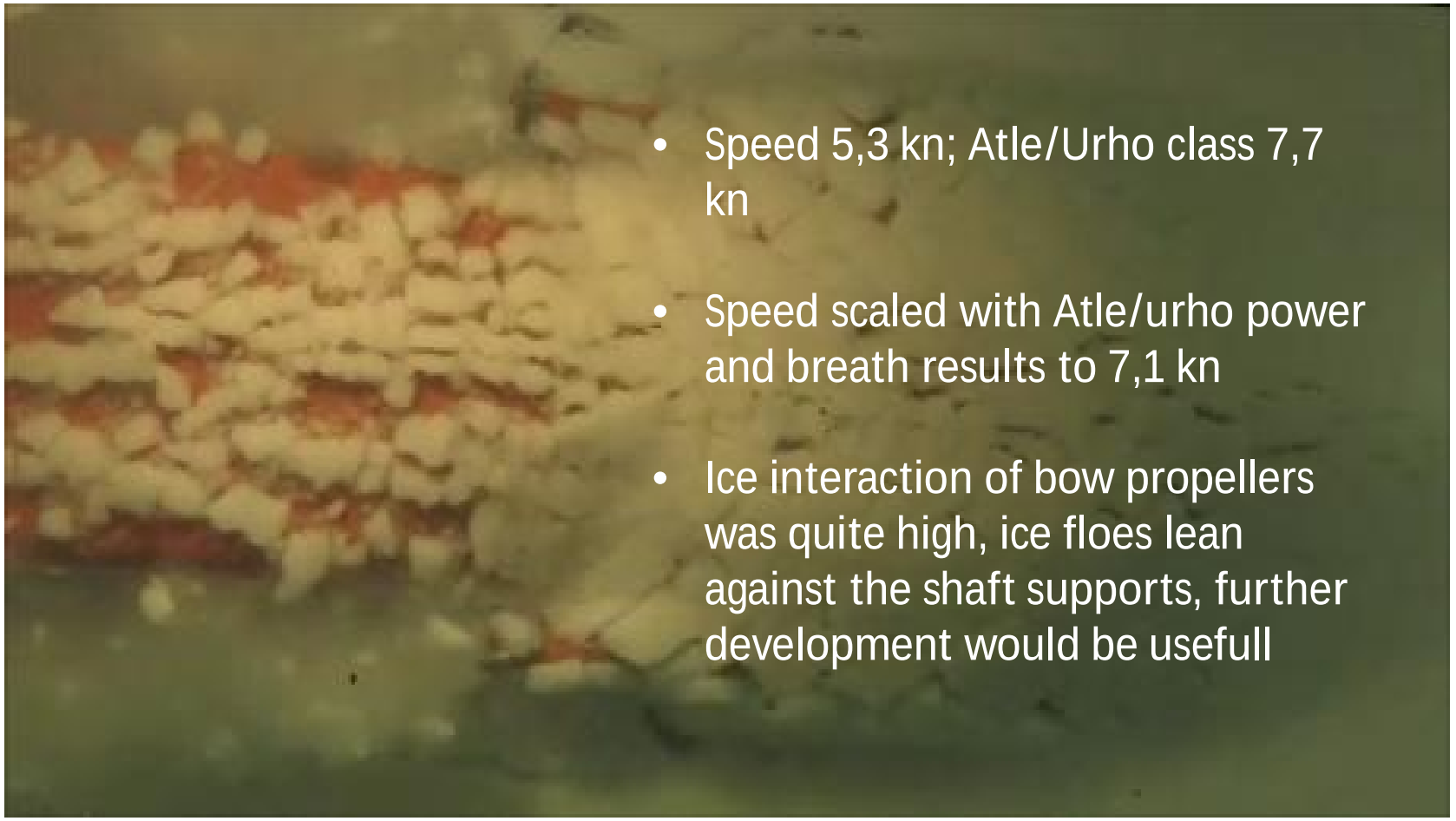
Level ice ahead H_{Ice} 0,87 m



- Speed 5,3 kn; Atle/Urho class 7,7 kn
- Speed scaled with Atle/urho power and breath results to 7,1 kn
- Ice interaction of bow propellers was quite high, ice floes lean against the shaft supports, further development would be usefull

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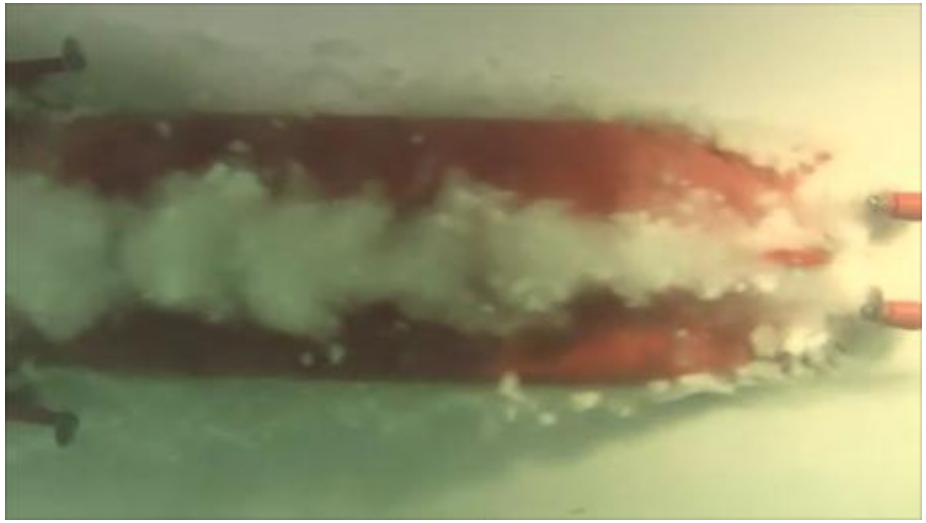
Level ice astern H_{Ice} 0,6 m

- Speed 6,6 kn, at same level like Botnica and higher than Urho
- Ice interaction with propellers quite low



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Consolidated channel ahead
H_{Ice} 1,2 m and 1,8 m

- Ice resistance in channel was quite low
- The wider bow with reamer propellers decreased the friction resistance

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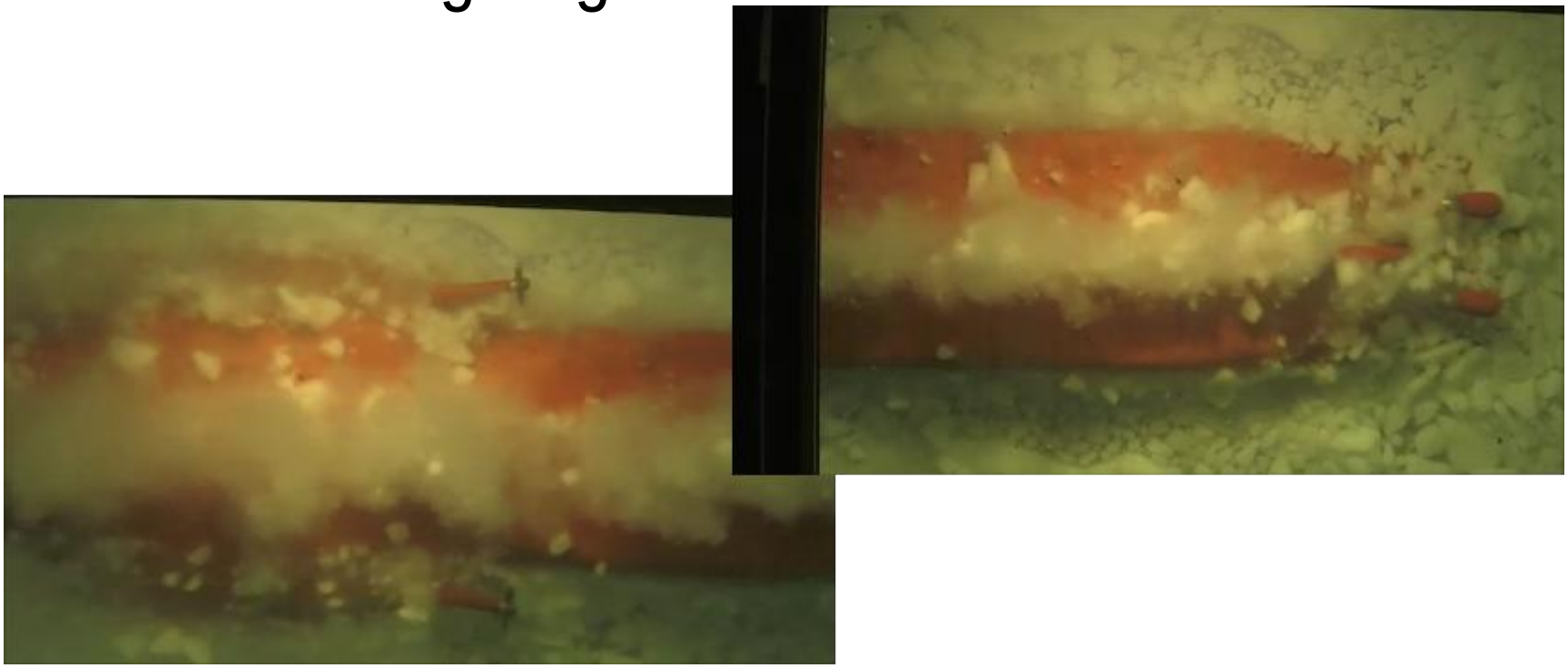
Consolidated channel astern H_{Ice} 0,6 m

- The bow propellers flow keep reamers clean of ice when going astern



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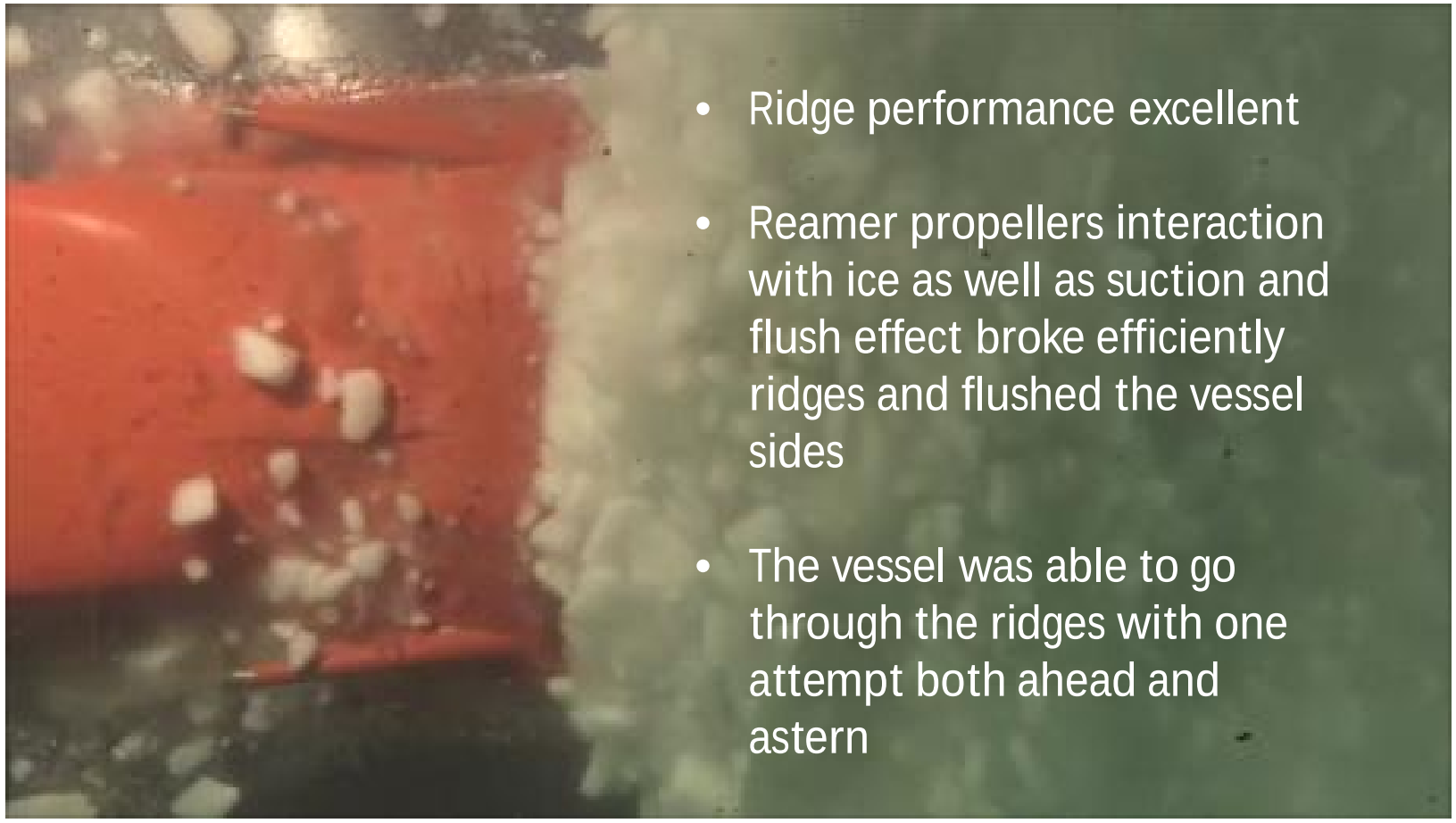
Consolidated ridge H_{Ice} 6 m



- Ridge performance excellent
- Reamer propellers interaction with ice as well as suction and flush effect broke efficiently ridges and flushed the vessel sides
- The vessel was able to go through the ridges with one attempt both ahead and astern

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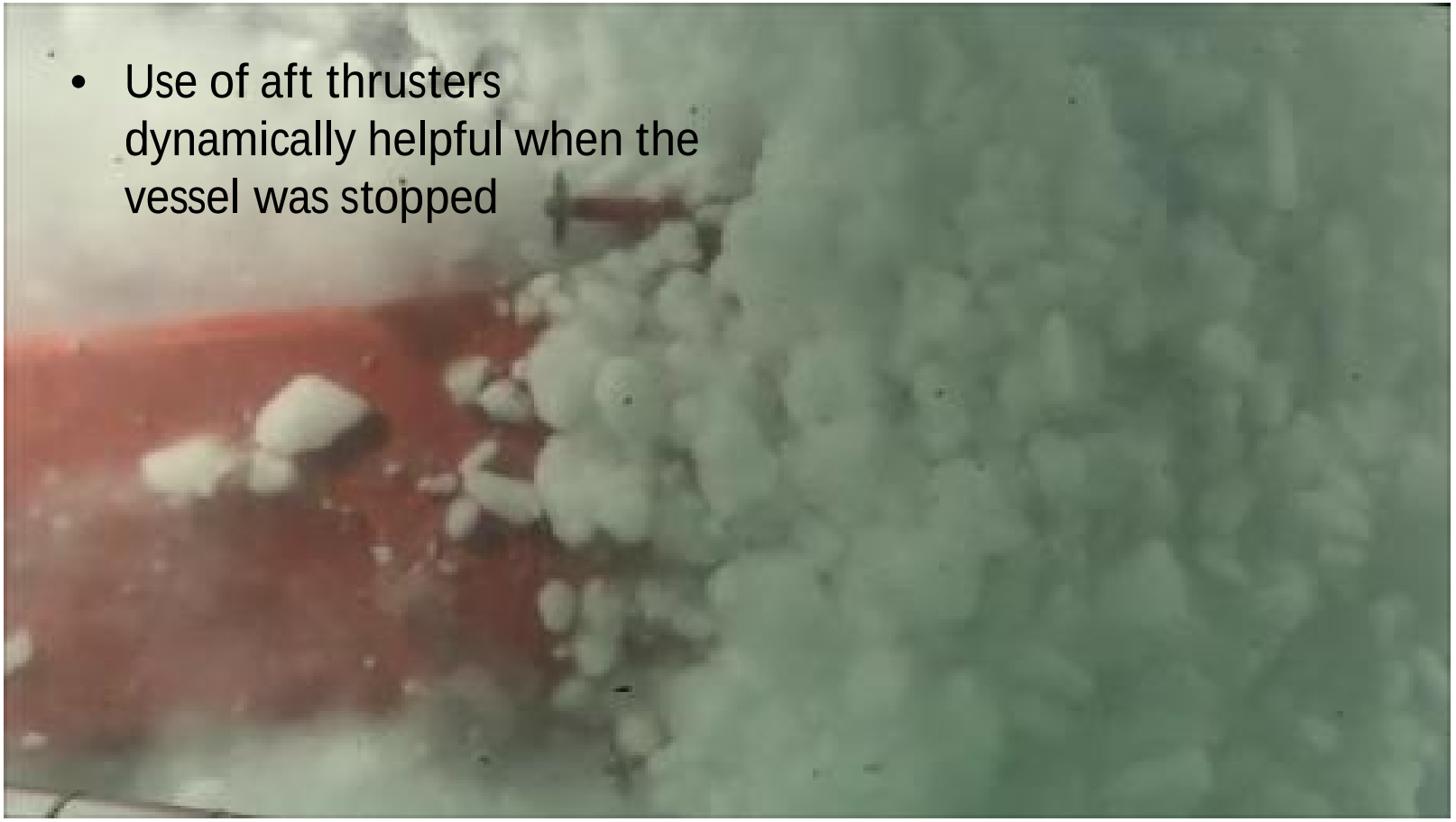
Consolidated ridge (Urho´s ridge)
H_{Ice} 9-5 m



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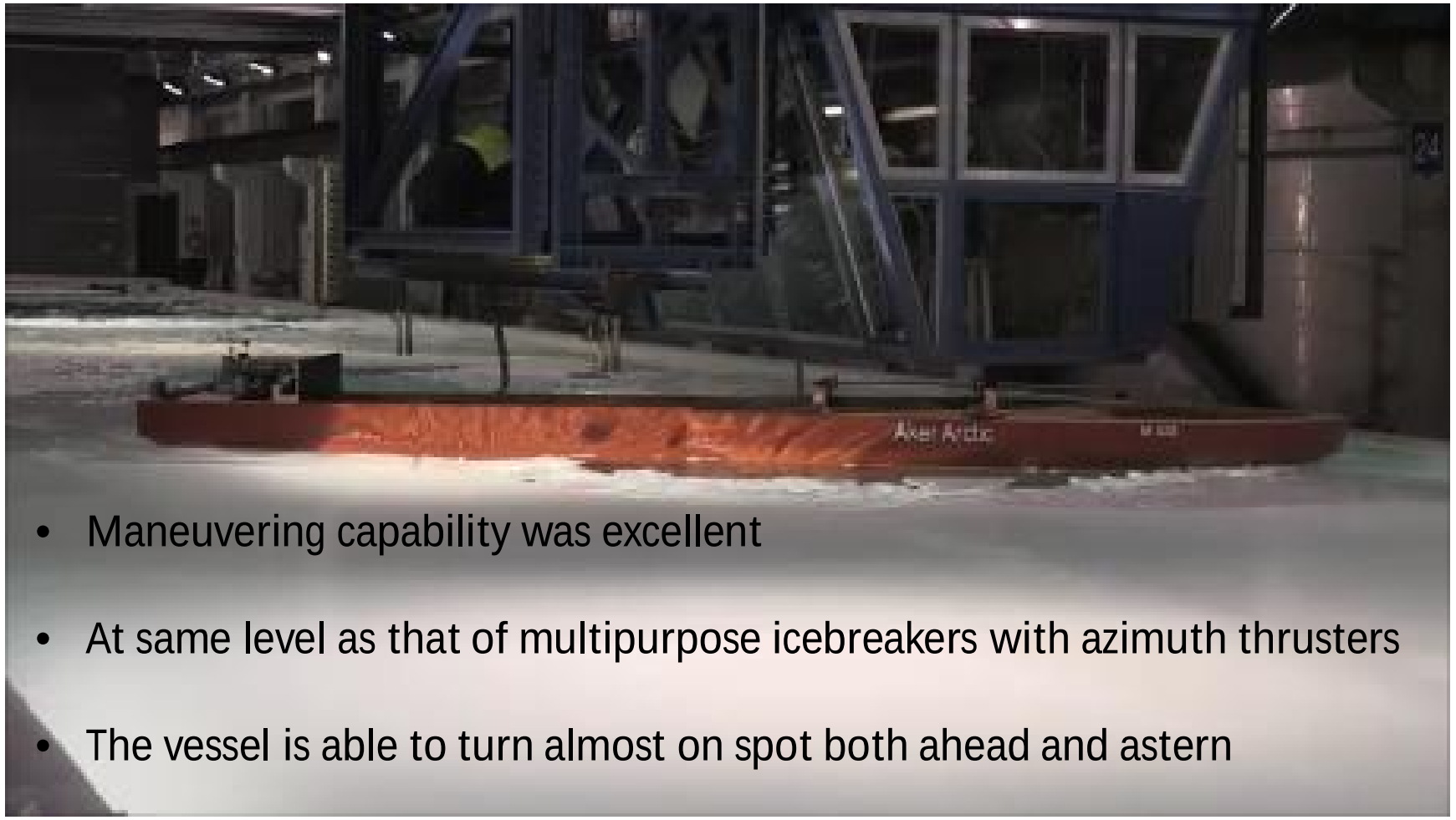
Turning test ahead H_{Ice} 0,6 m



- Maneuvering capability was excellent
- At same level as that of multipurpose icebreakers with azimuth thrusters
- The vessel is able to turn almost on spot both ahead and astern

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Summary

- The concept study and model tests showed that the removable bow icebreaker is feasible as a Baltic icebreaker
- The investment costs of the bow is about 25% of the price of a purpose built icebreaker

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Activity 2, Trimaran and Oblique icebreaker concepts

Mika Hovilainen
Project Manager
Aker Arctic Technology Inc
Helsinki 2016-03-29

Aker Arctic Technology Inc

- Founded in 2005 as independent company as spin-off from Kvaerner Masa-Yards arctic research and development organisation
- Employs today about 50 persons, experienced naval architects and arctic engineering specialists
- Annual turnover about 14 million Euros
- Aker Arctic's shareholders today:

Finnish Industry Investment Ltd	66,4 %
ABB Oy, Finland	16,8 %
Aker Solutions AS, Norway	16,8 %

- Working globally with major oil companies, industrial companies, shipyards, ship owners, classification societies and emerging industries
- Main services are ice going ship design and engineering, ice model testing and other arctic related consultation and engineering

Aker Arctic Technology Inc

- Main Office Helsinki
- Moscow Representative Office
- Akac Inc. (100% subsidiary), Victoria and St John's

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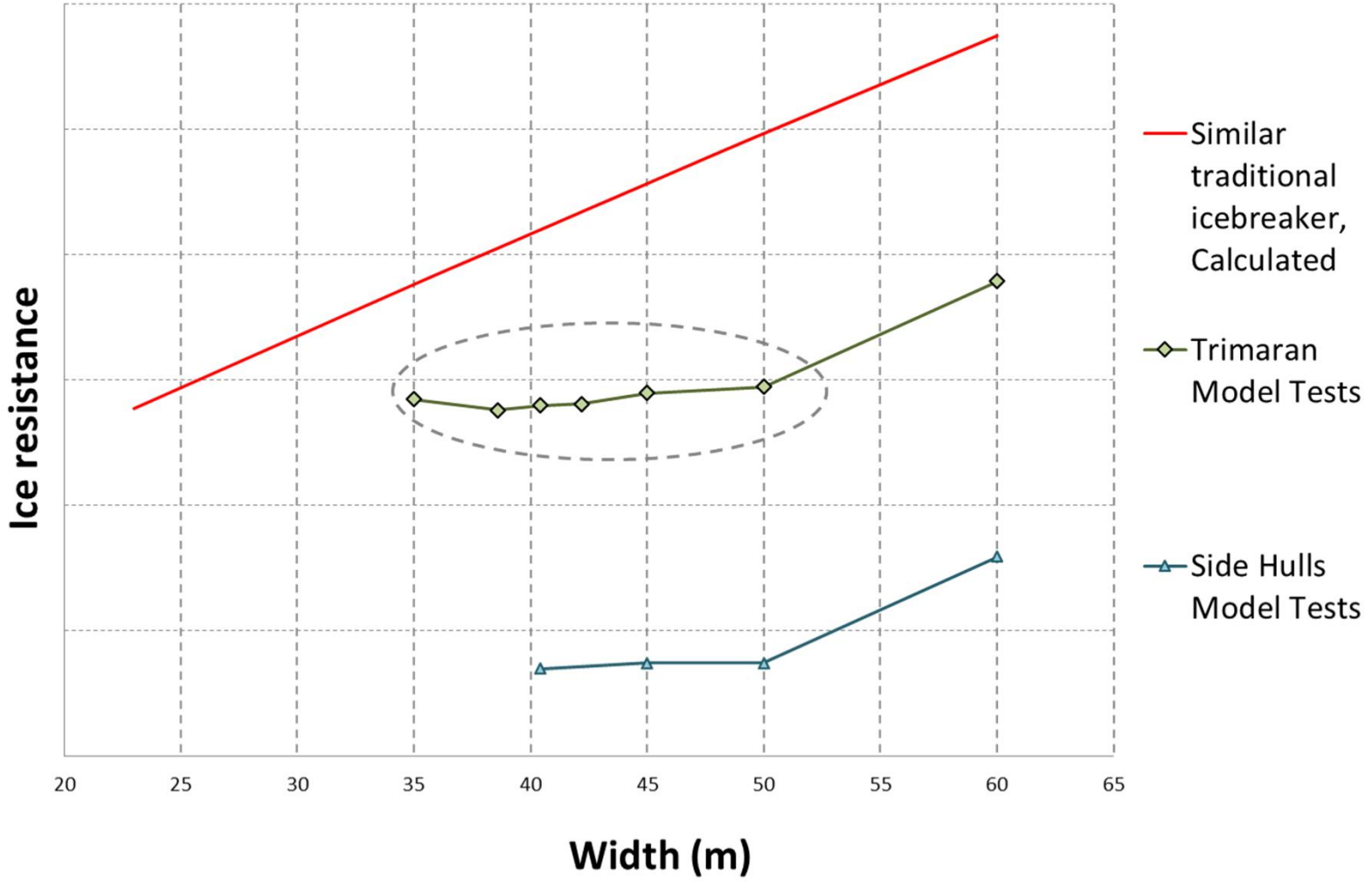
Trimaran icebreaker



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Trimaran icebreaker

- Aker Arctic has carried out extensive R&D around the trimaran icebreaker concept in the past years
  - Ice model tests
  - New calculation method for performance prediction of icebreaking trimaran
  - Crossdeck strength analysis
- As part of the WINMOS project, the trimaran icebreaker idea was refined into a realistic vessel concept
- Design basis:
  - Icebreaking vessel with ability to break wide channel with reasonable propulsion power
  - Secondary use as capable oil recovery vessel and project/oversize cargo carrier
  - Vessel length comparable to modern Baltic icebreakers
- Icebreaking capability previously verified in model tests
  - Low icebreaking resistance in level ice
  - Excellent maneuverability and ability to break out from channels
  - Continuous ridge penetration in astern direction
- Seakeeping tests were also carried out
  - to determine the behavior and of the novel hull form in heavy seas
  - To determine forces in Crossdeck in waves

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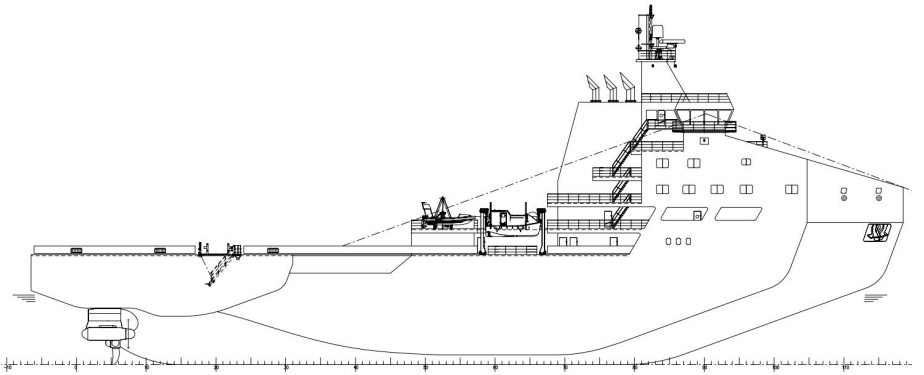
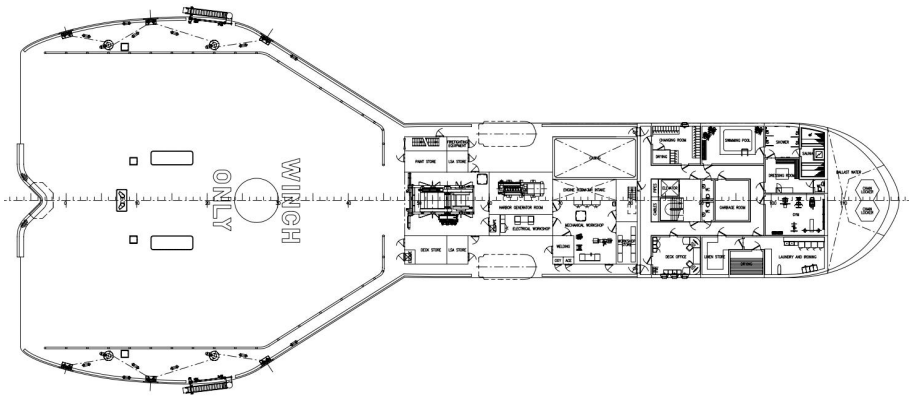
Trimaran icebreaker

Length over all	100.0 m
Length, dwl	92.2 m
Breadth, dwl	38.6 m
Draft, dwl/max	8.0 m/8.5 m
Power plant	Combined diesel-electric/mechanical: - one main engine mechanically coupled to CPP - two main generating sets - one harbour generator
Propulsion power	6,500 kW (mechanical CPP) 2 x 3,500 kW (diesel-electric azimuth thrusters)
Bollard pull	150 tonnes
Icebreaking capability	abt. 6 kn @ 0.8 m abt. 2 kn @ 1.5 m





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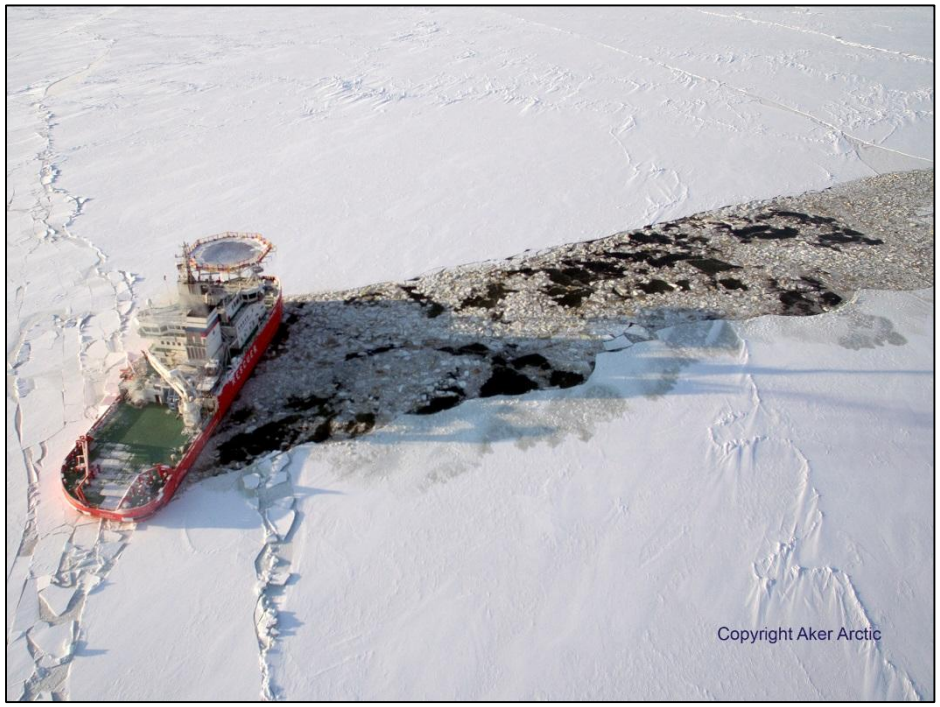
Oblique icebreaker

- Aker Arctic developed the oblique icebreaker concept in the 1990s as Aker ARC 100
- First vessel delivered and in service
  - NB508 Baltika, built by Arctech Helsinki Shipyard in 2014
  - Performance verified with full scale tests in the Russian Arctic; design icebreaking capability exceeded in ahead, astern and oblique icebreaking
  - Excellent overall operational capability in ice
- As part of the WINMOS project, the oblique icebreaker concept was further developed:
  - Higher ice class, increased icebreaking and general operational capability
  - Includes “lessons learned” from NB508 Baltika
  - Oil recovery capability retained from original concept
  - Escort capability (towing notch) added
  - Vessel size and propulsion power comparable to IB Voima



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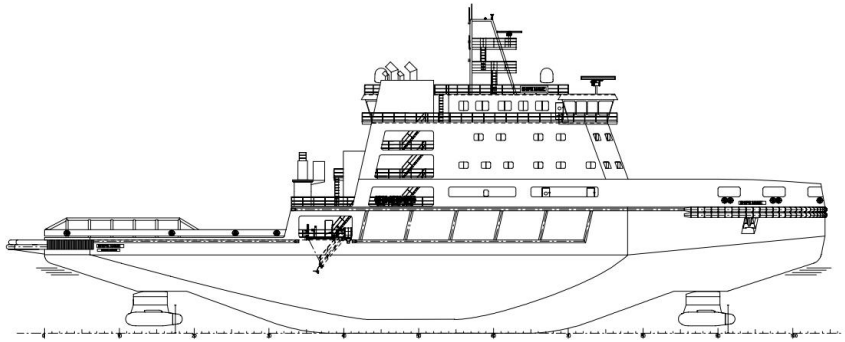
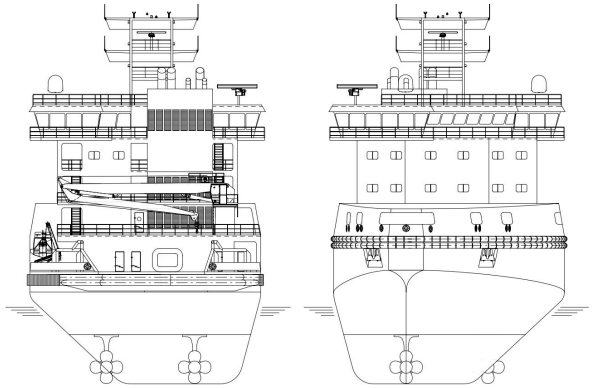
Oblique icebreaker

Length over all	87.5 m
Length, dwl	78.5 m
Breadth, dwl	20.0 m
Draft, dwl/max	7.0 m/7.5 m
Power plant	Diesel-electric: - three main generating sets - one harbour generator
Propulsion	3 x 3,500 kW (azimuth thrusters)
Icebreaking capability	abt. 5 kn @ 1.0 m abt. 2 kn @ 1.5 m abt. 4 kn @ 0.6 m (50 m wide channel)





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Winternavigation system change factors

- Traffic flows
  - Changes in transport volumes
  - New ship sizes
- Merchant vessels independent ice going capabilities
  - SOX > Fuel prize > no incentive to use extra power
  - EEDI > focus on open water performance
- Operator competence
  - Modern manning practices reduce possibilities to assure long term experience base onboard
- Climate change
  - Time span, variation between winters
- Renewal of icebreaker capacity
  - Scale of investment
  - Availability from possible commercial sector of icebreaking

EEDI and SOX will increase need of assistance due to weaker merchant vessels of the future

Assisted vessels, development trends

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EXAMPLE of basic icebreaker, StBy/Ops 210/180 d/y, rate 3%
Investment and operations, no fuel 286,5M€/50y

Vessel name	Perusmurtaja 1
Vessel type (1= basic icebreaker, 2 = multi-use icebreaker)	1
Fuel type (1=diesel, 2= LNG)	1
Start of use, dd.mm.yyyy	1.7.2016
No. of years in use after start of use	50
Capital cost (return requirement), % p.a.	3,00 %
Investment cost (remaining unamortized investment cost if existing vessel), €	95 000 000
Renovation 1 (used to calculate annual capital cost), €	8 000 000
Renovation 2 (used to calculate annual capital cost), €	5 000 000
Capital amortization period, years	20
Renovation 1 amortization period, years	15
Renovation 2 amortization period, years	15
Yearly personnel cost (multi-purpose icebreakers), €/year	0
Yearly personnel cost (basic icebreaker), €/year	1 200 000
Variable personnel cost (basic icebreaker), €/operation day	5 000
Yearly maintenance and management cost, €/year	700 000
Level of use 1, %	0 %
Additional income 1, €/day (for days in a year excluding stand-by days)	0
Life cycle 1 period, years	0
Level of use 2, %	0 %
Additional income 2, €/day (for days in a year excluding stand-by days)	0
Life cycle 2 period, years	0
Level of use 3, %	0 %
Additional income 3, €/day (for days in a year excluding stand-by days)	0
Life cycle 3 period, years	0
Stand-by fee, €/stand-by day	23 000
Operation fee, €/operation day	5 000